CLAIMS

1. A control device for a mobile body that comprises a desired gait determining means for determining a desired gait composed of a desired motion and a desired floor reaction force of a mobile body, such as a mobile robot having three or more ground contact portions connected through the intermediary of a plurality of joints such that mutual relative heights thereof can be manipulated, and a floor reaction force detecting means for detecting or estimating an actual floor reaction force acting on each of the ground contact portions, and controls the operation of the mobile body to make a gait of the mobile body follow a desired gait,

wherein the ground contact portions are classified into a tree structure such that each of the ground contact portions becomes a leaf node, and an intermediate node exists between the leaf node and a root node having all the leaf nodes as descendant nodes, and

relative to a B-th node, which is each node in the tree structure, if the B-th node is the leaf node, then a floor reaction force acting on a ground contact portion that is the leaf node is defined as the node floor reaction force of the B-th node, and if the B-th node has child nodes, then the resultant force of the node floor reaction forces of all child nodes of the B-th node is defined as the node floor reaction force of the B-th node,

the control device for a mobile body, comprising:

a means for determining an actual node floor reaction force as the actual value of the node floor reaction force of each node from the detected or estimated actual floor reaction force of each ground contact portion;

a means for determining a desired node floor reaction force as the desired value of a node floor reaction force of each node on the basis of at least a desired floor reaction force of the desired gait; and

a node operation controlling means that determines, on each of C-th nodes, which is a node having a plurality of ground contact portions as descendant nodes, the correction amounts of the desired relative heights of a plurality of ground contact portions belonging to the C-th node on the basis of at least the relative relationship among the actual node floor reaction forces of each child node of the C-th node and the relative relationship among the desired node floor reaction forces of each child node of the C-th node, determines a corrected desired motion by adding at least a first correction of the desired relative heights of the plurality of ground contact portions belonging to each C-th node to a desired motion of the desired gait on the basis of a correction amount obtained by combining the determined correction amounts of all C-th nodes, and operates the joints such that the corrected desired motion that has been determined is satisfied.

2. A control device for a mobile body that comprises a

desired gait determining means for determining a desired gait composed of a desired motion and a desired floor reaction force of a mobile body, such as a mobile robot having three or more ground contact portions connected through the intermediary of a plurality of joints such that mutual relative heights thereof can be manipulated, and a floor reaction force detecting means for detecting or estimating an actual floor reaction force acting on each of the ground contact portions, and controls the operation of the mobile body to make a gait of the mobile body follow a desired gait,

wherein the ground contact portions are classified into a tree structure such that each of the ground contact portions becomes a leaf node, and an intermediate node exists between the leaf node and a root node having all the leaf nodes as descendant nodes, and

relative to each of B-th nodes, which is each node in the tree structure, if the B-th node is the leaf node, then a floor reaction force acting on a ground contact portion that is the leaf node is defined as the node floor reaction force of the B-th node, and if an A-th node has child nodes, then the resultant force of the node floor reaction forces of all child nodes of the B-th node is defined as the node floor reaction force of the B-th node,

the control device for a mobile body, comprising:

relative to a predetermined C-th node that is an intermediate node having a plurality of ground contact

portions as descendant nodes,

a means for determining an actual node floor reaction force as the actual value of a node floor reaction force of each child node of at least the C-th node from the detected or estimated actual floor reaction force of each ground contact portion;

a means for determining a desired node floor reaction force as the desired value of a node floor reaction force of each child node of at least the C-th node on the basis of at least a desired floor reaction force of the desired gait; and

a node operation controlling means that determines a corrected desired motion by adding at least a first correction of the desired relative heights of the plurality of ground contact portions belonging to the C-th node to the desired motion of the desired gait on the basis of at least a relative relationship among the actual node floor reaction forces of each child node of the C-th node and a relative relationship among the desired node floor reaction forces of each child node of the C-th node such that the relative relationship among the actual node floor reaction forces of the child nodes of the C-th node approximates the relative relationship among the desired node floor reaction forces of each child node of the C-th node, and operates the joints such that the corrected desired motion that has been determined is satisfied.

3. The control device for a mobile body according to

Claim 1, wherein

a weight has been set on each node in the tree structure, and relative to a B-th node, which is each node in the tree structure, if the B-th node is the leaf node, then the height of a ground contact portion that is the leaf node is defined as the height of the B-th node, and if the B-th node has child nodes, then a weighted mean value, which uses the weight, of the heights of all child nodes of the B-th node is defined as the height of the B-th node, and

if the node operation controlling means determines the corrected desired motion for only one arbitrary node among the C-th nodes by adding a first correction of the desired relative heights of a plurality of ground contact portions belonging to that one node to a desired motion of the desired gait, then a desired height of that one node in the corrected desired motion is maintained at a desired height in the desired motion.

4. The control device for a mobile body according to Claim 2, wherein

a weight has been set on each node in the tree structure, and relative the B-th node, which is each node in the tree structure, and if the B-th node is a leaf node, then the height of a ground contact portion that is the leaf node is defined as the height of the B-th node, and if the B-th node has child nodes, then the weighted mean value, which uses said weight, of the heights of all child

nodes of the B-th node is defined as the height of the B-th node, and

if the node operation controlling means determines, only on the C-th node, the corrected desired motion by adding a first correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node to the desired motion, then the desired height of the C-th node in the corrected desired motion is maintained at a desired height in the desired motion.

5. A control device for a mobile body that comprises a desired gait determining means for determining a desired gait composed of a desired motion and a desired floor reaction force of a mobile body, such as a mobile robot having three or more ground contact portions connected through the intermediary of a plurality of joints such that mutual relative heights thereof can be manipulated, and a floor reaction force detecting means for detecting or estimating an actual floor reaction force acting on each of the ground contact portions, and controls the operation of the mobile body to make a gait of the mobile body follow a desired gait,

wherein the ground contact portions are classified into a tree structure such that each of the ground contact portions becomes a leaf node, and an intermediate node exists between the leaf node and a root node having all the leaf nodes as descendant nodes, and

relative to a B-th node, which is each node in the

tree structure, if the B-th node is the leaf node, then a floor reaction force acting on a ground contact portion that is the leaf node is defined as the node floor reaction force of the B-th node, and if the B-th node has child nodes, then the resultant force of the node floor reaction forces of all child nodes of the B-th node is defined as the node floor reaction force of the B-th node, and further, if the point at which the horizontal component or a parallel-to-floor component of the moment of a node floor reaction force of the B-th node becomes zero is defined as the node floor reaction force central point of the B-th node,

the control device for a mobile body, comprising:

a means for determining a desired node floor reaction force central point, which is the desired position of a node floor reaction force central point of each node, on the basis of at least one of a desired motion and a desired floor reaction force of the desired gait;

a means for determining an actual node floor reaction force as the actual value of a node floor reaction force of each node from the detected or estimated actual floor reaction force of each ground contact portion; and

a node operation controlling means that determines, on each of the C-th nodes, which is a node having a plurality of ground contact portions as descendant nodes,

by using, as a control amount, one of

a difference (Mc_act-Mc_dmd) between an actual moment (Mc_act), which is the moment caused by the actual node floor reaction force of the C-th node to act on a desired node floor reaction force central point of the C-th node, and a desired value (Mc_dmd) of a moment that should act on the desired node floor reaction force central point of the C-th node,

a difference (Mc_f-Mc_dmd) between a moment (Mc_f), which is obtained by subtracting the moment caused by the actual node floor reaction force of each child node of the C-th node to act on a desired node floor reaction force central point of the child node from the actual moment (Mc_act) of the C-th node, and a desired value (Mc_dmd) of a moment that should act on the desired node floor reaction force central point of the C-th node,

a value of the difference (ΔP) between the position of the point at which the horizontal component or the parallel-to-floor component of the moment of the actual node floor reaction force of the C-th node becomes zero and the position of the desired node floor reaction force central point of the C-th node, and

a value of the difference (ΔPf) between the position of the point at which the horizontal component or the parallel-to-floor component of the moment, which is obtained by subtracting the moment caused by the actual node floor reaction force of each child node of the C-th

node to act on the desired node floor reaction force central point of the child node from the moment of the actual node floor reaction force (Mc_act) of the C-th node, becomes zero and the position of the desired node floor reaction force central point of the C-th node,

a correction amount of the desired relative heights of a plurality of ground contact portions belonging to the C-th node, for each C-th node, such that the control amount approximates zero on the basis of the control amount, and also determines, on the basis of a correction amount obtained by combining the determined correction amounts of all C-th nodes, a corrected desired motion obtained by adding at least a first correction of the desired relative heights of the plurality of ground contact portions belonging to each C-th node to a desired motion of the desired gait, then operates the joints such that the determined corrected desired motion is satisfied.

6. A control device for a mobile body that comprises a desired gait determining means for determining a desired gait composed of a desired motion and a desired floor reaction force of a mobile body, such as a mobile robot having three or more ground contact portions connected through the intermediary of a plurality of joints such that mutual relative heights thereof can be manipulated, and a floor reaction force detecting means for detecting or estimating an actual floor reaction force acting on each of the ground contact portions, and controls the

operation of the mobile body to make a gait of the mobile body follow a desired gait,

wherein the ground contact portions are classified into a tree structure such that each of the ground contact portions becomes a leaf node, and an intermediate node exists between the leaf node and a root node having all the leaf nodes as descendant nodes, and

relative to each of B-th nodes, which is each node in the tree structure, if the B-th node is the leaf node, then a floor reaction force acting on a ground contact portion that is the leaf node is defined as the node floor reaction force of the B-th node, and if the B-th node has child nodes, then the resultant force of the node floor reaction forces of all child nodes of the B-th node is defined as the node floor reaction force of the B-th node, and further, if the point at which the horizontal component or a parallel-to-floor component of the moment of the node floor reaction force of the A-th node becomes zero is defined as the node floor reaction force central point of the B-th node,

the control device for a mobile body, comprising:

relative to a predetermined C-th node that is an intermediate node having a plurality of ground contact portions as descendant nodes,

a means for determining a desired node floor reaction force central point, which is the desired position of a node floor reaction force central point of

at least the C-th node, on the basis of at least the desired gait;

a means for determining an actual node floor reaction force as the actual value of a node floor reaction force of at least the C-th node from the detected or estimated actual floor reaction force of each ground contact portion; and

a node operation controlling means that determines, by using, as a control amount, one of

a difference (Mc_act-Mc_dmd) between an actual moment (Mc_act), which is the moment caused by the actual node floor reaction force of the C-th node to act on a desired node floor reaction force central point of the C-th node, and a desired value (Mc_dmd) of a moment that should act on the desired node floor reaction force central point of the C-th node,

a difference (Mc_f-Mc_dmd) between a moment (Mc_f), which is obtained by subtracting the moment caused by the actual node floor reaction force of each child node of the C-th node to act on a desired node floor reaction force central point of the child node from the actual moment (Mc_act) of the C-th node, and a desired value (Mc_dmd) of a moment that should act on the desired node floor reaction force central point of the C-th node,

a value of the difference (ΔP) between the position of the point at which the horizontal component or the parallel-to-floor component of the moment of the actual

node floor reaction force of the C-th node becomes zero and the position of the desired node floor reaction force central point of the C-th node, and

a value of the difference (ΔPf) between the position of the point at which the horizontal component or the parallel-to-floor component of the moment, which is obtained by subtracting the moment caused by the actual node floor reaction force of each child node of the C-th node to act on the desired node floor reaction force central point of the child node from the moment of the actual node floor reaction force (Mc_act) of the C-th node, becomes zero and the position of the desired node floor reaction force central point of the C-th node,

a corrected desired motion by adding at least a first correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node to the desired motion of the desired gait such that the control amount approximates zero on the basis of the control amount, and operates the joints such that the determined corrected desired motion is satisfied.

7. The control device for a mobile body according to Claim 5,

wherein a weight has been set on each node in the tree structure, and relative to a B-th node, which is each node in the tree structure, if the B-th node is the leaf node, then the height of a ground contact portion that is the leaf node is defined as the height of the B-th node,

and if the B-th node has child nodes, then a weighted mean value, which uses the weight, of the heights of all child nodes of the B-th node is defined as the height of the B-th node, and

when the node operation controlling means determines the corrected desired motion for only one arbitrary node among C-th nodes by adding a first correction of the desired relative heights of the plurality of ground contact portions belonging to that one node to the desired motion, the desired height of that one node in the corrected desired motion is maintained at a desired height in the desired motion.

8. The control device for a mobile body according to Claim 6,

wherein a weight has been set on each node in the tree structure, and relative to a B-th node, which is each node in the tree structure, if the B-th node is the leaf node, then the height of a ground contact portion that is the leaf node is defined as the height of the B-th node, and if the B-th node has child nodes, then the weighted mean value, which uses said weight, of the heights of all child nodes of the B-th node is defined as the height of the B-th node, and

when the node operation controlling means determines, only on the C-th node, the corrected desired motion by adding a first correction of the desired relative heights of a plurality of ground contact portions belonging to the

C-th node to the desired motion, the desired height of the C-th node in the corrected desired motion is maintained at the desired height in the desired motion.

9. The control device for a mobile body according to Claim 7 or 8, wherein the means for determining a desired node floor reaction force central point determines the desired node floor reaction force central points and weights of the C-th node and each of the descendant nodes thereof such that the weighted mean value, which uses the weight, of the positions of the desired node floor reaction force central points of each child node of the C-th node will be the desired node floor reaction force central point of the C-th node.

10. The control device for a mobile body according to Claim 5, wherein the node operation controlling means determines, for each of the C-th nodes, the correction amounts of the desired relative heights of the plurality of ground contact portions belonging to the C-th node on the basis of a movement amount of a desired node floor reaction force central point of each child node of the C-th node, the movment amount being obtained when the desired node floor reaction force central point of each child node of the C-th node is rotated about the desired node floor reaction force central point of the C-th node by the rotational amount determined on the basis of at least the control amount.

11. The control device for a mobile body according to

Claim 6, wherein the node operation controlling means determines the corrected desired motion by adding a first correction of the desired relative heights of the plurality of ground contact portions belonging to the C-th node to the desired motion on the basis of the movement amount of the desired node floor reaction force central point of each child node of the C-th node, the movement amount being obtained when the desired node floor reaction force central point of each child node of the C-th node is rotated about the desired node floor reaction force central point of the C-th node by the rotational amount determined on the basis of at least the control amount.

12. The control device for a mobile body according to Claim 7, wherein the node operation controlling means determines a corrected desired motion, which is obtained by adding a first correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node to the desired motion, by manipulating the mutual relative heights of the child nodes of the C-th node on the basis of the movement amount of the desired node floor reaction force central point of each child node of the C-th node, the movement amount being obtained when the desired node floor reaction force central point of each child node of the C-th node is rotated about the desired node floor reaction force central point of the C-th node by the rotational amount determined on the basis of at least the control amount.

13. The control device for a mobile body according to any one of Claims 3, 4, 7 and 8, wherein on each node having child nodes in the tree structure, the weights of all child nodes of each node are set such that the total sum of the weights of all the child nodes becomes one.

14. The control device for a mobile body according to any one of Claims 3, 4, 7 and 8, further comprising a means for variably setting the weight of the each node, wherein if a leaf node corresponding to each ground contact portion not in contact with the ground is defined as a D-th node, then the means for setting weights sets the weight of each D-th node or the weight of at least one node of the ancestor nodes of the D-th node to zero.

15. The control device for a mobile body according to any one of Claims 1, 2, 5 and 6, further comprising an actual posture inclination detecting means for detecting or estimating the actual posture inclination of a predetermined portion, such as the base body, of the mobile body,

wherein, when determining the corrected desired motion, the node operation controlling means determines the corrected desired motion by further adding, to the desired motion, a correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node on the basis of a difference between the actual posture inclination and the desired posture inclination of the predetermined portion in a

desired motion of the desired gait such that the difference approximates zero.

16. The control device for a mobile body according to Claim 5 or 6, further comprising an actual posture inclination detecting means for detecting or estimating the actual posture inclination of a predetermined portion, such as the base body, of the mobile body,

wherein the node operation controlling means comprises a means for correcting at least either the desired value of the moment that should act on the desired node floor reaction force central point of the C-th node or the desired node floor reaction force central point of the C-th node on the basis of a posture inclination error, which is the difference between the actual posture inclination and the desired posture inclination of the predetermined portion in the desired motion, such that the posture inclination error approximates zero, and determines the control amount by using the desired value of a moment or the desired node floor reaction force central point, which have been corrected, in place of the desired value of a moment or a desired node floor reaction force central point before the correction.

17. The control device for a mobile body according to Claim 5 or 6, each of the ground contact portions being connected to a base body of the mobile body through the intermediary of connecting mechanisms such that they are movable with respect to the base body, the control device

comprising:

a desired node floor reaction force distributing means for determining, on each of E-th nodes, which is a node having child nodes in the tree structure, the translational force component of a desired node floor reaction force of each leaf node belonging to the E-th node on the basis of at least the desired floor reaction force of the desired gait such that the horizontal component or the parallel-to-floor component of a moment caused by a desired node floor reaction force, which is the desired value of the E-th node floor reaction force, to act on the desired node floor reaction force central point of the E-th node becomes zero,

wherein the node operation controlling means comprises a means for estimating, on the basis of at least the translational force component of a desired node floor reaction force of each leaf node belonging to the C-th node, the amount of a deformation that occurs in a connecting mechanism between the base body and each ground contact portion belonging to the C-th node and in the ground contact portion when the translational force component of the desired node floor reaction force acts on each of the ground contact portion belonging to the C-th node, and when determining the corrected desired motion, the node operation controlling means determines the corrected desired motion by further adding, to the desired motion, a second correction of the desired height of each

of a plurality of ground contact portions belonging to the C-th node to cancel the estimated deformation amount.

18. The control device for a mobile body according to any one of Claims 3, 4, 7 and 8, each of the ground contact portions being connected to a base body of the mobile body through the intermediary of connecting mechanisms such that they are movable with respect to the base body, the control device comprising:

a desired node floor reaction force distributing means that determines, on each of E-th nodes, which is a node having a parent node in the tree structure, the translational force component of a desired node floor reaction force of the E-th node on the basis of at least the desired floor reaction force of the desired gait such that the translational force component of a desired node floor reaction force, which is the desired value of the E-th node floor reaction force, takes a value obtained by multiplying the translational force component of a desired node floor reaction force of the parent node of the E-th node by the weight of the E-th node,

wherein the node operation controlling means comprises a means for estimating, on the basis of at least the translational force component of a desired node floor reaction force of each leaf node belonging to the C-th node, the amount of a deformation that occurs in a connecting mechanism between the base body and each ground contact portion belonging to the C-th node and in the

ground contact portion when the translational force component of the desired node floor reaction force acts on each of the ground contact portion belonging to the C-th node, and when determining the corrected desired motion, the node operation controlling means determines the corrected desired motion by further adding, to the desired motion, a second correction of the desired height of each of a plurality of ground contact portions belonging to the C-th node to cancel the estimated deformation amount.

19. The control device for a mobile body according to Claim 5 or 6, each of the ground contact portions being connected to a base body of the mobile body through the intermediary of connecting mechanisms such that they are movable with respect to the base body, the control device further comprising:

an actual posture inclination detecting means for detecting or estimating the actual posture inclination of a predetermined portion, such as the base body, of the mobile body;

a means for correcting the desired node floor reaction force central point of at least the C-th node on the basis of a posture inclination error, which is the difference between the actual posture inclination and the desired posture inclination of the predetermined portion in the desired motion, such that the posture inclination error approximates zero; and

a desired node floor reaction force distributing

means that determines at least the translational force component of a desired node floor reaction force, which is the desired value of the node floor reaction force of each descendant node of the C-th node, out of the desired node floor reaction force, which is the desired value of the node floor reaction force of each node, on the basis of at least the desired floor reaction force of the desired gait such that the horizontal component or the parallel-to-floor component of the moment of a desired node floor reaction force acting on the corrected desired node floor reaction force central point of the C-th node becomes zero,

wherein the node operation controlling means comprises a means for estimating, on the basis of at least the translational force component of a desired node floor reaction force of each leaf node belonging to the C-th node, the amount of a deformation that occurs in a connecting mechanism between the base body and each ground contact portion belonging to the C-th node and in the ground contact portion when the translational force component of the desired node floor reaction force acts on each of the ground contact portion belonging to the C-th node, and when determining the corrected desired motion, the node operation controlling means determines the control amount by using the corrected desired node floor reaction force central point of the C-th node in place of the desired node floor reaction force central point before the correction and also determines the corrected desired

motion by further adding, to the desired motion, a second correction of the desired height of each of a plurality of ground contact portions belonging to the C-th node to cancel the estimated deformation amount.

20. The control device for a mobile body according to Claim 5 or 6, each of the ground contact portions being connected to a base body of the mobile body through the intermediary of connecting mechanisms such that they are movable with respect to the base body, the control device comprising:

an actual posture inclination detecting means for detecting or estimating an actual posture inclination of a predetermined portion, such as the base body, of the mobile body;

a means for determining the desired value of a moment that should act on the desired floor reaction force central point of at least the C-th node on the basis of a posture inclination error, which is the difference between the actual posture inclination and the desired posture inclination of the predetermined portion in the desired motion, such that the posture inclination error approximates zero; and

a desired node floor reaction force distributing means that determines at least the translational force component of a desired node floor reaction force, which is the desired value of a node floor reaction force of each descendant node of the C-th node, out of the desired node

floor reaction force, which is the desired value of a node floor reaction force of each node, on the basis of at least a floor reaction force of the desired gait such that the moment of a desired node floor reaction force acting on the desired node floor reaction force central point of the C-th node becomes the determined desired value,

wherein the node operation controlling means comprises a means for estimating, on the basis of at least the translational force component of a desired node floor reaction force of each leaf node belonging to the C-th node, the amount of a deformation that occurs in a connecting mechanism between the base body and each ground contact portion belonging to the C-th node and in the ground contact portion when the translational force component of the desired node floor reaction force acts on each ground contact portion belonging to the C-th node, and when determining the corrected desired motion, the node operation controlling means determines the control amount by using the determined desired value of the moment of the C-th node and also determines the corrected desired motion by further adding, to the desired motion, a second correction of the desired height of each of a plurality of ground contact portions belonging to the C-th node to cancel the estimated deformation amount.

21. The control device for a mobile body according to any one of Claims 3, 4, 7, and 8, each of the ground contact portions being connected to a base body of the mobile body

through the intermediary of connecting mechanisms such that they are movable with respect to the base body, the control device further comprising:

an actual posture inclination detecting means for detecting or estimating the actual posture inclination of a predetermined portion, such as the base body, of the mobile body;

a means for correcting the weight of each descendant node of at least the C-th node on the basis of the posture inclination error, which is the difference between the actual posture inclination and the desired posture of the predetermined portion in the desired motion, such that a posture inclination error approximates zero; and

a desired node floor reaction force distributing means that determines at least the translational force component of a desired node floor reaction force, which is the desired value of a node floor reaction force of each descendant node of the C-th node, out of the desired node floor reaction force, which is the desired value of the node floor reaction force of each node, on the basis of at least the desired floor reaction force of the desired gait, so as to take a value obtained by multiplying the translational force component of a desired node floor reaction force of a parent node of each descendant node by the corrected weight of the descendant node,

wherein the node operation controlling means comprises a means for estimating, on the basis of at least

the translational force component of a desired node floor reaction force of each leaf node belonging to the C-th node, the amount of a deformation that occurs in a connecting mechanism between the base body and each ground contact portion belonging to the C-th node and in the ground contact portion when the translational force component of the desired node floor reaction force acts on each ground contact portion belonging to the C-th node, and when determining the corrected desired motion, the node operation controlling means determines the corrected desired motion by further adding, to the desired motion, a second correction of the desired height of each of a plurality of ground contact portions belonging to the C-th node to cancel the estimated deformation amount.

22. The control device for a mobile body according to Claim 1 or 5, wherein each of the ground contact portions is connected to a base body of the mobile body such that they are movable with respect to the base body, and

when determining the corrected desired motion, the node operation controlling means determines the corrected desired motion by further adding, to the desired motion, a correction of a desired posture of the base body to restrain slippages, such as twists, of each of the ground contact portions belonging to the C-th node on a floor surface.

23. The control device for a mobile body according to Claim 2 or 6, wherein each of the ground contact portions

is connected to a base body of the mobile body such that they are movable with respect to the base body, and

when determining the corrected desired motion, the node operation controlling means determines the corrected desired motion by further adding, to the desired motion, a correction of a desired posture of the base body to restrain slippages, such as twists, of each of the ground contact portions belonging to the C-th node on a floor surface.

24. The control device for a mobile body according to Claim 22, wherein the node operation controlling means determines the corrected desired motion such that the direction of the segment that connects the desired overall floor reaction force central point of the mobile body, which depends on a desired floor reaction force of the desired gait, and the overall center-of-gravity of the mobile body or a predetermined representative point of the base body of the mobile body in the corrected desired motion is substantially identical to the direction of the segment in the desired gait.

25. The control device for a mobile body according to Claim 23, wherein the node operation controlling means determines the corrected desired motion such that the direction of the segment that connects the desired overall floor reaction force central point of the mobile body, which depends on a desired floor reaction force of the desired gait, and the overall center-of-gravity of the

mobile body or a predetermined representative point of the base body of the mobile body in the corrected desired motion is substantially identical to the direction of the segment in the desired gait.

26. The control device for a mobile body according to Claim 22, wherein the node operation controlling means determines the corrected desired motion such that the horizontal position of the overall center-of-gravity of the mobile body or the horizontal position of a predetermined representative point of the base body of the mobile body in the corrected desired motion is substantially identical to the horizontal position in the desired motion.

27. The control device for a mobile body according to Claim 23, wherein the node operation controlling means determines the corrected desired motion such that the horizontal position of the overall center-of-gravity of the mobile body or the horizontal position of a predetermined representative point of the base body of the mobile body in the corrected desired motion is substantially identical to the horizontal position in the desired motion.

28. The control device for a mobile body according to Claim 22, wherein the mobile body is a robot comprising a plurality of link mechanisms extended from its base body, and at least one link mechanism among the plurality of link mechanisms is provided with a joint at least in an

intermediate portion thereof between a distal end thereof and an end thereof adjacent to the base body, and the intermediate portion is the ground contact portion.

29. The control device for a mobile body according to Claim 23, wherein the mobile body is a robot equipped with a plurality of link mechanisms extended from its base body, and at least one link mechanism among the plurality of link mechanisms is provided with a joint at least in an intermediate portion between its distal end and its end adjacent to the base body, and the intermediate portion is a ground contact portion belonging to the C-th node.

30. The control device for a mobile body according to Claim 28, wherein the intermediate portion is provided with an elastic member that resiliently deforms when coming into contact with the ground.

31. The control device for a mobile body according to Claim 29, wherein the intermediate portion is provided with an elastic member that resiliently deforms when coming into contact with the ground.

32. The control device for a mobile body according to Claim 22, wherein the mobile body comprises a plurality of link mechanisms extended from its base body, each of which has one or more joints, at least one link mechanism among the link mechanisms and the base body are provided with ground contact portions, and ground contact portions that belong to at least one of the C-th nodes include at least a ground contact portion of the base body and ground

contact portions of one or more link mechanisms among the plurality of link mechanisms.

33. The control device for a mobile body according to Claim 23, wherein the mobile body is provided with a plurality of link mechanisms extended from its base body, each of which has one or more joints, at least one link mechanism among the link mechanisms and the base body are provided with ground contact portions, and ground contact portions that belong to the C-th node include at least a ground contact portion of the base body and ground contact portions of one or more link mechanisms among the plurality of link mechanisms.

34. The control device for a mobile body according to Claim 32, wherein a ground contact portion of the base body is provided with an elastic member that resiliently deforms when coming into contact with the ground.

35. The control device for a mobile body according to Claim 33, wherein a ground contact portion of the base body is provided with an elastic member that resiliently deforms when coming into contact with the ground.

36. The control device for a mobile body according to any one of Claims 1, 2, 5, and 6, wherein a weight has been set on each node in the tree structure, and

if processing in which, when a predetermined type of state amount, such as a height or a floor reaction force, is associated with each leaf node in the tree structure, the state amount of each node having child nodes is

defined as a weighted mean value, which uses the weight, of the state amounts of all child nodes of the node, the value obtained by subtracting a state amount of a parent node of the node from the state amount of the node is determined as a node relative state amount of the node on each node except a root node, and zero is determined as a relative state amount of the root node, is defined as the processing for hierarchically relativizing the predetermined type of state amount on each node,

if a node relative floor reaction force Fn_rel(n=1,2,...) hierarchically relativized on each node is determined on the basis of a floor reaction force Fn(n=1,2,...) acting on each of the ground contact portions, which are the leaf nodes, and when a vector (Fa1_rel,Fa2_rel,...,Far_rel) having, as its elements, the node relative floor reaction forces of all child nodes aj (j=1,2,...,r. r denotes the total number of the child nodes of an n-th node) of an n-th node, which is an arbitrary node having child nodes, is represented by a linear linkage of a plurality of predetermined mutually independent vectors R(j)(j=1,2,...,r-1) that are all orthogonal to a vector (Wa1,Wa2,...,War) having the weights of all child nodes of the n-th node as its elements, a vector having a coefficient of the linear linkage as its element is defined as a node expansion floor reaction force moment Mn_exp of the n-th node, and

if a node relative height Zn_rel(n=1,2,...)

hierarchically relativized on each node is determined on the basis of a height Zn (n=1,2,...) of each of the ground contact portions, which are the leaf nodes, and when a vector (Za1_rel, Za2_rel,...,Zar_rel) having the node relative heights of all child nodes aj (j=1,2,...,r. r denotes the total number of the child nodes of an n-th node) of the n-th node as its elements is expressed by a linear linkage of the plurality of the predetermined mutually independent vectors R(j)(j=1,2,...,r-1), a vector having a coefficient of the linear linkage as its element is defined as a node expansion inclination angle θn of the n-th node,

then, the node operation controlling means determines the corrected desired motion by adding, to the desired motion, a first correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node by using at least the node expansion floor reaction force moment Mn_exp or the node expansion inclination angle θn of the C-th node.

37. The control device for a mobile body according to Claim 36, further comprising: a means for determining a desired floor reaction force that should act on each ground contact portion belonging to at least the C-th node on the basis of at least the desired floor reaction force of the desired gait,

wherein the node operation controlling means comprises a means for determining a desired node expansion

moment, which is a desired value of the node expansion moment of the C-th node, on the basis of the desired floor reaction force of each ground contact portion belonging to the C-th node, a means for determining an actual node expansion moment, which is an actual value of the node expansion moment of the C-th node on the basis of an actual floor reaction force of each ground contact portion belonging to the C-th node, and a means for determining a manipulated variable of the node expansion inclination angle of the C-th node on the basis of the actual node expansion moment and the desired node expansion moment, and determines the corrected desired motion by adding, to the desired motion, a first correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node on the basis of the determined manipulated variable of the node expansion inclination angle.

38. The control device for a mobile body according to any one of Claims 1, 2, 5, and 6, further comprising: a floor configuration estimating means for estimating a parameter that specifies the relative heights of the ground contact surfaces of a plurality of ground contact portions belonging to at least the C-th node as the floor configuration parameter that represents a floor configuration,

wherein the node operation controlling means determines the corrected desired motion by further adding

a third correction of the desired relative heights of a plurality of the ground contact portions belonging to the C-th node on the basis of an estimated value of the floor configuration parameter when determining the corrected desired motion.

39. The control device for a mobile body according to Claim 38, further comprising a means for determining an actual node floor reaction force, which is the actual value of a node floor reaction force of each child node of at least the C-th node, from an actual floor reaction force of each ground contact portion belonging to the C-th node,

wherein the floor configuration estimating means performs estimation while sequentially updating the floor configuration parameter on the basis of a past value of an estimated value of the floor configuration parameter, a difference between the corrected desired motion and the desired motion, the corrected motion, at least either a detected value or an estimated value of an actual joint displacement, which is a displacement amount of each joint of the mobile body, the actual posture inclination, and a relative relationship among the actual node floor reaction forces of each child node of at least the C-th node.

40. The control device for a mobile body according to Claim 38, each of the ground contact portions being connected to the base body of the mobile body through the intermediary of connecting mechanisms such that they are

movable with respect to the base body, the control device comprising:

a deformation amount detecting means for detecting or estimating the amounts of deformations that occurs in the connecting mechanisms between the base body and each of the ground contact portions belonging to the C-th node and in the ground contact portions,

wherein the floor configuration estimating means performs estimation while sequentially updating the floor configuration parameter on the basis of a past value of an estimated value of the floor configuration parameter, a difference between the corrected desired motion and the desired motion, the corrected motion, at least either a detected value or an estimated value of an actual joint displacement, which is a displacement amount of each joint of the mobile body, the actual posture inclination, and the deformation amounts associated with each of the ground contact portions belonging to at least the C-th node.

41. The control device for a mobile body according to Claim 40, wherein the deformation amount detecting means estimates the deformation amounts on the basis of the actual floor reaction forces of each of the ground contact portions.

42. The control device for a mobile body according to Claim 38, wherein a weight of each node in the tree structure has been set, and relative to a B-th node, which is each node in the tree structure, if the B-th node is

the leaf node, then the height of the ground contact surface of a ground contact portion that is the leaf node is defined as the height of the ground contact surface of the B-th node and if the B-th node has child nodes, then a weighted mean value, which uses the weight, of the heights of the ground contact surfaces of all child nodes of the B-th node is defined as the height of the ground contact surface of the B-th node,

then the floor configuration parameter estimated by the floor configuration estimating means is a parameter that specifies the relative relationship among the heights of the ground contact surfaces of a plurality of child nodes of the C-th node.

43. The control device for a mobile body according to Claim 42, wherein, when at least one of the child nodes of the C-th node is likely to float, the floor configuration estimating means estimates the floor configuration parameter that specifies the relative relationship among the heights of the ground contact surfaces of the plurality of child nodes, while maintaining the relative height of the ground contact surface of that child node, which is likely to float, at a fixed value.

44. The control device for a mobile body according to Claim 38, wherein the floor configuration estimating means estimates the floor configuration parameter by using a low-pass filter so as to alleviate fluctuations in the floor configuration parameter.

45. The control device for a mobile body according to Claim 38, wherein a weight has been set on each node in the tree structure, and

if processing in which, when a predetermined type of state amount, such as a height or a floor reaction force, is associated with each leaf node in the tree structure, the state amount of each node having child nodes takes a weighted mean value, which uses the weight, of the state amounts of all child nodes of the node, a value obtained by subtracting a state amount of a parent node of each node from the state amount of the node is determined as a node relative state amount of the node on each node except a root node, and zero is determined as a relative state amount of the root node, is defined as the processing for hierarchically relativizing the predetermined type of state amount on each node,

if a node relative floor reaction force Fn_rel(n=1,2,...) hierarchically relativized on each node is determined on the basis of a floor reaction force Fn(n=1,2,...) acting on each of the ground contact portions, which are the leaf nodes, and if a vector (Fa1_rel,Fa2_rel,...,Far_rel) having, as its elements, the node relative floor reaction forces of all child nodes aj (j=1,2,...,r. r denotes the total number of the child nodes of an n-th node) of an n-th node, which is an arbitrary node having child nodes, is represented by a linear linkage of a plurality of predetermined mutually

independent vectors R(j)(j=1,2,…,r-1) that are all orthogonal to a vector (Wa1,Wa2,…,War) having the weights of all child nodes of the n-th node as its elements, then a vector having a coefficient of the linear linkage as its element is defined as a node expansion floor reaction force moment Mn_exp of the n-th node, and

if a node relative height Zn_rel(n=1,2,…) hierarchically relativized on each node is determined on the basis of a height Zn(n=1,2,…) of the ground contact surface of each of the ground contact portions, which are the leaf nodes, and if a vector (Za1_rel, Za2_rel,…,Zar_rel) having the node relative heights of all child nodes aj (j=1,2,…,r. r denotes the total number of the child nodes of an n-th node) of the n-th node as its elements is expressed by a linear linkage of the plurality of the predetermined mutually independent vectors R(j)(j=1,2,…,r-1), then a vector having a coefficient of the linear linkage as its element is defined as a node expansion inclination angle θn of the n-th node, and

the floor configuration estimating means estimates the floor configuration parameter by using at least the node expansion floor reaction force moment Mn_exp or the node expansion inclination angle θn of the C-th node.

46. The control device for a mobile body according to Claim 45, wherein, relative to a B-th node, which is each node in the tree structure, if the B-th node is the leaf

node, then the height of the ground contact surface of the ground contact portion that is the leaf node is defined as the height of the ground contact surface of the B-th node, and if the B-th node has child nodes, then a weighted mean value, which uses the weight, of the heights of the ground contact surfaces of all child nodes of the B-th node, is defined as the height of the ground contact surface of the B-th node, and

the floor configuration parameter includes a parameter that uses the node expansion inclination angle to indicate the relative height of the ground contact surface of each child node of the C-th node.

47. The control device for a mobile body according to Claim 45, further comprising a means for determining a desired floor reaction force that should act on each ground contact portion belonging to at least the C-th node on the basis of at least the desired floor reaction force of the desired gait,

wherein the node operation controlling means comprises a means for determining a desired node expansion moment, which is a desired value of the node expansion moment of the C-th node, on the basis of the desired floor reaction force of each ground contact portion belonging to the C-th node, a means for determining an actual node expansion moment, which is the actual value of the node expansion moment of the C-th node on the basis of the actual floor reaction force of each ground contact portion

belonging to the C-th node, and a means for determining a manipulated variable of the node expansion inclination angle of the C-th node on the basis of the actual node expansion moment and the desired node expansion moment, and determines the corrected desired motion by adding, to the desired motion, a first correction of the desired relative heights of a plurality of ground contact portions belonging to the C-th node on the basis of the determined manipulated variable of the node expansion inclination angle.